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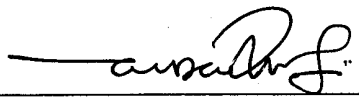

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TEACHING AND LEARNING MODULE BASED ON PICK AND PLACE MOBILE ROBOT

SHAHNOR SUZAINI BIN NOR SAZALI

A project report submitted in fulfillment of the
requirements for the award of the degree of
Bachelor of Engineering (Electrical - Mechatronics)

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Specially dedicated to *mak* and *abah* for your support.

Also to my supervisor that always help me

to conduct this project.

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ABSTRACT

Teaching and learning module based on pick and place mobile robot is a teaching tools developed to help students to learn the basics of robotics. In everyday life, the robots are getting more and more important to solve and simplify human tasks. Therefore, the development of robotics education module should be taken seriously. This project is a combination of two essential elements which are electronics circuit design and software design. The project also involves installing new microcontroller unit for the existing mobile robot, building wireless communication module, and creating educational module based on mobile robot in the form of computer program. This robot is also equipped with wireless communication module in order to enable communication between the robot and the computer. This robot can be controlled in two ways. First way is by using the arrow keys in the basic GUI controller. The second way is through the GUI controller with record and replay ability. For operating the robot controller using the GUI controller with record and replay ability, user can control the robot by pressing certain keys on the computer. In addition, students can also program the robot to repeat the operation that has been done. About educational module, it is in the form of a special program for students to learn the basics of robotics and also to understand the structure behind this robot. These include the display of basic notes, program flowcharts, basic term definitions, and basic programming.

ABSTRAK

Modul pengajaran dan pembelajaran berdasarkan kepada robot bergerak ambil dan letak adalah alat pengajaran yang dibangunkan untuk membantu pelajar belajar tentang asas robotik. Dalam kehidupan seharian, robot menjadi semakin dan semakin penting untuk menyelesaikan dan memudahkan tugas manusia. Oleh itu, pembangunan modul untuk pendidikan robotik seharusnya diambil serius. Projek ini adalah kombinasi daripada dua elemen penting iaitu merekabentuk litar elektronik dan merekabentuk program komputer. Projek ini juga melibatkan pemasangan mikropengawal baru kepada robot sedia-ada, membina modul komunikasi tanpa wayar, dan mencipta module pendidikan berdasarkan robot bergerak. Robot bergerak ini dilengkapi dengan module komunikasi tanpa wayar untuk membolehkan komunikasi antara robot dan komputer.Robot ini boleh dikawal dengan dua cara. Cara yang pertama adalah dengan menggunakan kekunci arah dalam pengawal GUI asas. Cara yang kedua adalah dengan melalui pengawal GUI dengan kebolehan merakam dan memain semula. Untuk operasi robot menggunakan pengawal GUI dengan kebolehan merakam dan memain semula, pengguna boleh mengawal, merakam dan memainkan semula operasi robot yang telah dilakukan. Berkenaan dengan module pendidikan, ianya adalah dalam bentuk program komputer untuk pelajar belajar tentang asas robotik dan juga untuk memahami struktur program disebalik robot tersebut. Hal ini termasuklah paparan tentang nota asas, carta alir program robot, dan asas pemprograman sesuatu robot.

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LIST OF SYMBOLS

A	-	Ampere
Hz	-	Frequency, Hertz
MHz	-	Mega Hertz
RM	-	Malaysia Ringgit
S	-	second
V	-	Voltage

LIST OF ABBREVIATIONS

IC	-	Integrated circuit
UART	-	Universal asynchronous receiver/transmitter
MHz	-	Mega hertz
USB	-	Universal serial bus
ICSP	-	In circuit serial programming
AC	-	Alternate current
DC	-	Direct current
PWM	-	Pulse width modulator
MCU	-	Multipoint control unit
SPI	-	Serial peripheral interface
ISM	-	International Safety Management
RF	-	Radio frequency
bps	-	byte per second
dB	-	deciBell
GUI	-	Graphical user interface
IDE	-	Integrated development environments
RM	-	Ringgit Malaysia

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Teaching and learning module based on pick and place mobile robot is a tools created to help student to learn robotics. This project is the continuation from the two previous projects that had be done by Nirot Oh Ah Paa [1] and Ahmad Faizzudeen Bin Ab Aziz Fauzi [2] that titled as *Rekabentuk Robot Bergerak Berlengan* and Search, Pick And Place Mobile Robot, respectively.

In order to complete this project, three main tasks which include installing, programming, and constructing a new microcontroller unit to the existing mobile robot, to construct a wireless communication module, and to write a robot control program on a computer. This project also involves the design and development training kit as a guide and lesson for the student. The robot can be controlled by using a main computer program that has several modes. The purpose of these different methods of operation is to expose the students about the various example of controlling a robot. The computer program will be written in visual basic language.

1.2 Problem Statement

Robotics education is a powerful tool to keep students interested and motivated in learning technology, computer, sciences, engineering etc. In the last two decades, educational robots contribute to increase learning achievements in teaching of science, technology, engineering and mathematics [3]. Technology-based models and methods of teaching and learning are very helpful, because they can provide many alternative ways of teaching, which learners select as they engage in their educational experiences [4]. Particularly, the educational robotics technologies enable students to control the behaviour of a tangible model (robot) by means of a virtual environment in which students investigate everyday phenomena [5].

With our current situation in this modern world that facing the advancement of technology, it is relevant and good for us to start thinking how to attract the younger generation to become good robotics field. Therefore, the attractive tools to educate the student in this field need to be created in order to generate more expertise in robotics especially in our country in the future.

1.3 Project Objectives

The main objective of this project is to develop a robotic education tools for student that can boost the student knowledge and interest towards robotic education. To achieve this objective, the following sub-objectives need to be done in this project:

i. To rebuild an existing search, pick and place mobile robot by installing a new microcontroller unit, designing the wireless communication system, and constructing computer program to control robot by using computer.

ii. To design and prepare the teaching and learning modules.
iii. To write a computer program based on the teaching and learning module suitable for undergraduate students.

1.4 Project Scopes

The following are the guidelines that listed to ensure the project is conducted within its boundary of mechanical hardware modification, electronics including sensors and programming. This is to ensure the project is heading in the right direction to achieve its intended objectives. The scopes of project are:

i. To use existing mobile robot designed and built by Nirot Oh A/L Ah Paa [1].
ii. To use Arduino Mega as the microcontroller for the mobile robot.
iii. To use nRF24L01 and Arduino Uno as a wireless communication module.
iv. To use Microsoft Visual Studio 2010 software and visual basic as a programming language to build the education module.

1.5 Report Layout

This report consists of 6 chapters. Chapter 1 is the introduction to this project. This chapter consist of project background, problem statement, project objectives and project scopes. Meanwhile, Chapter 2 will discuss about literature review. This chapter consists of many important and useful insights to conduct the project.

Chapter 3 gives the research methodology of this project. It explains about the software and electronic design for this project. In Chapter 4, it presents the results and discussion of the result. In chapter 5, it will show you how this project is managed. Finally, the conclusion and recommendation of the project will be discussed in chapter 6.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discusses about the previous project and related works that are used as references to complete this project. Other than that, the theory of electronic and visual basic also being shown and discussed. This includes the knowledge of system controller (Arduino Mega and Arduino Uno), nRF24L01 communication module, and motor driver IC.

2.2 Microcontroller

A microcontroller is a small computer on a single integrated circuit (IC) containing a processor core, memory, and programmable input/output peripherals [6]. Microcontrollers are designed for embedded applications in contrast to the microprocessors used in personal computer or other general purpose applications [7]. This microcontroller is frequently used for remote controls toys, mobile robot and office machine [8].

2.2.1 Arduino Mega

Arduino Mega is an open source single-board microcontroller based on the Atmega1280. It has 54 digital input/ output pins (of which 14 can be used as PWM outputs). 16 analogue inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [9]. It does contain everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. Besides that, Arduino hardware is programmed using a wiring-based language (syntax and libraries), similar to C++ with some slight simplifications and modifications. Figure 2.1 shows the top view of Arduino Mega [9]. Figure 2.1 shows Arduino Mega microcontroller.

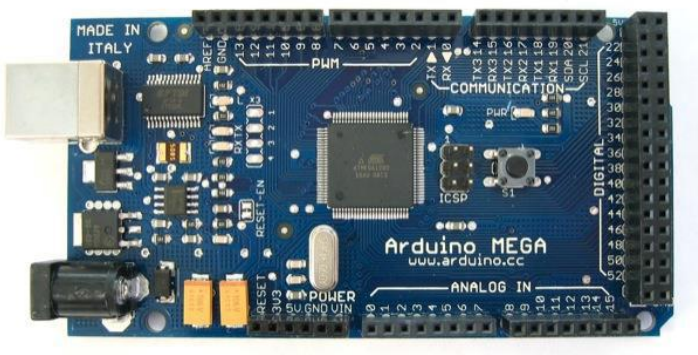

Figure 2.1: Arduino Mega

2.2.2 Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328 (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button [9]. It contains everything needed to support

the microcontroller, simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Figure 2.2 shows Arduino Uno microcontroller.

Figure 2.2: Arduino Uno

2.3 Motor Drivers

Motor driver or motor controller is a device or a group of devices that serves to govern in some predetermined manner the performance of an electric motor [10]. Motor drivers are used to control the motor operation such as start, stop, forward or reverse the rotation, and regulating the speed.

2.3.1 L298 Arduino Motor Driver Shield

This motor shield allows Arduino to drive two channel DC motors. It uses a L298N chip which delivers output current up to 2A each channel. The speed control is achieved through conventional PWM which can be obtained from Arduino's PWM

output Pin 5 and 6. The enable/disable function of the motor control is signalled by Arduino Digital Pin 4 and 7 [11]. The Motor shield can be powered directly from Arduino or from external power source. It is strongly encouraged to use external power supply to power the motor shield. Figure 2.3 shows the Arduino motor driver Shield.

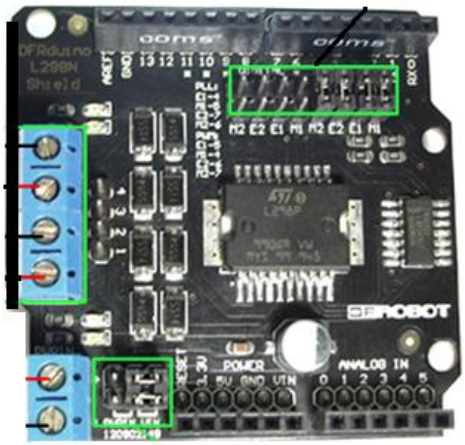

Figure 2.3: L298 Arduino Motor Driver Shield

Other specifications of this motor driver are as below:

i. Logic control voltage：5V (From Arduino)
ii. Motor driven voltage：4.8～35V (From Arduino or External Power Source)
iii. Logic supply current Iss：≤36mA
iv. Motor driven current Io：≤2A
v. Maximum power consumption：25W（T=75℃）
vi. PWM or PLL speed control mode

2.3.2 L293D Motor Driver IC

The L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. Figure 2.4 shows the integrated circuit of L293D.

Figure 2.4: L293D IC

2.4 Wireless Communication Module

Wireless communication is proven to increase the flexibility of a robot. In wired communication, the robot working area is limited by the communication cable length.

2.4.1 nRF24L01 Wireless Module

The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst™), suitable for ultra-low power wireless applications. The nRF24L01 is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz [12].

To design a wireless communication system with the nRF24L01, you are simply need a microcontroller and a few external passive components. You can operate and configure the nRF24L01+ through a Serial Peripheral Interface (SPI)[12]. Figure 2.5 shows the nRF24L01 device.

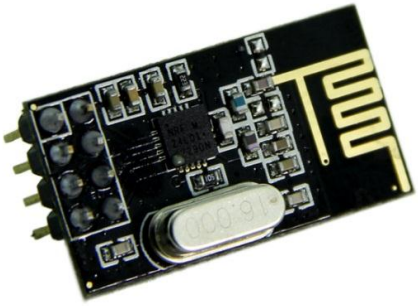

Figure 2.5: An nRF24L01 transceiver

This module based on Nordic nRF24L01, highly integrated, ultra-low power (ULP) 2Mbps RF transceiver for the 2.4GHz ISM (Industrial, Scientific and Medical) band [12]. Nordic nRF24L01 integrates a complete 2.4GHz RF transceiver, RF synthesizer, and baseband logic including the Enhanced ShockBurst™ hardware protocol accelerator supporting a high-speed SPI interface for the application controller [12]. The specifications of this motor driver are as below:

i. Power supply : 1.9~3.6V
ii. IO port working voltage : 0~3.3v / 5v

iii. Transmitting rate : +7dB

iv. Receiving sensitivity : ⩽ -90dB

v. Transmission range : 250m in open area

vi. Dimension : 15x29mm

Figure 2.6 shows the pins of nRF24L01 transceiver. This transceiver need to be connected to the microcontroller to make the serial peripheral interfacing possible.

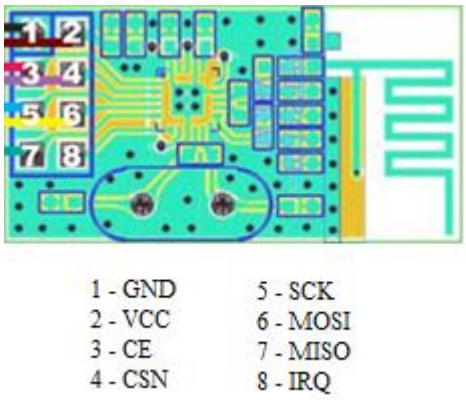

Figure 2.6: nRF24L01 transceiver pins

Based on Table 2.1, the Arduino Uno and Arduino Mega pins used to be connected to the nRF24L01.

Table 2.1: Arduino Uno and Arduino Mega SPI pins

MODULE PIN	DESCRIPTION	UNO	MEGA
1	GND	GND	GND
2	VCC	3.3V (See note)	3.3V (See note)
3	CE	DIO 8	DIO 8
4	CSN	DIO 7	DIO 7
5	SCK	DIO 13	DIO 52
6	MOSI	DIO 11	DIO 51
7	MISO	DIO 12	DIO 50
8	IRQ		

2.5 Related Works

To conduct this project, the related project are studied and referred. These are including armed mobile robot design project, pick and place mobile robot project, and Scorbase software for scorbot.

2.5.1 Armed Mobile Robot Design

This project has been done in 2002 by Nirot Oh A/L Ah Paa. Armed mobile robot can be define as a mobile robot with pick and place object from one place to another place function[1]. This robot can be divided into two main parts which are, mobile robot and robot arm. Mobile robots have the capability to move around in their environment and are not fixed to one physical location [2]. Robot arm referred as a part that equipped with a robot manipulator that can be modelled as a chained of several rigid bodies or links connected in series by neither revolute or prismatic joint driven by manipulator[13]. Figure 2.7 shows the mechanical part of the robot.

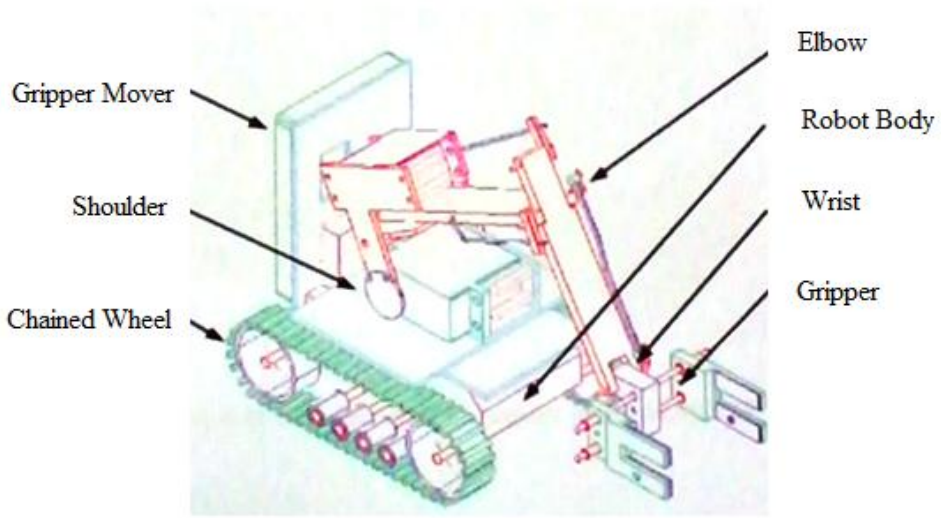

Figure 2.7: The mechanical design of the mobile robot

The objectives of this project are to use basic and easy to purchase components in the local market, to design the mobile robot that has high efficiency to move in rough or waving surface, to design arm system by servo motor, and to design gripper system that capable to pick and place various type of object. Other than that, this project also developed to have robot program with basic function.

In this project, Nirot Oh is using MCH68hC11 controller produced by Motorolla which now are not relevant any more in term of efficiency and costing nowadays. Therefore the best way to revive this robot is by using Arduino mega based on ATmega1280 as a microcontroller.

2.5.2 Search, Pick and Place Mobile Robot

The project that has been done by Ahmad Faizzudeen Bin AB Aziz Fauzi [2] is the continuation of the robot created by Nirot Oh A/L Ah Paa [1]. The objectives of this project are to build a new microcontroller unit and the wireless communication module to an existing mobile robot for use in basic robot operation and simple robot programming [2]. The robot is designed to perform search, pick and place operations and by using a communication module enable the mobile robot to be wirelessly controlled using a computer. Figure 2.8 shows the structure of the mobile robot. Meanwhile Figure 2.9 shows the GUI controller design.

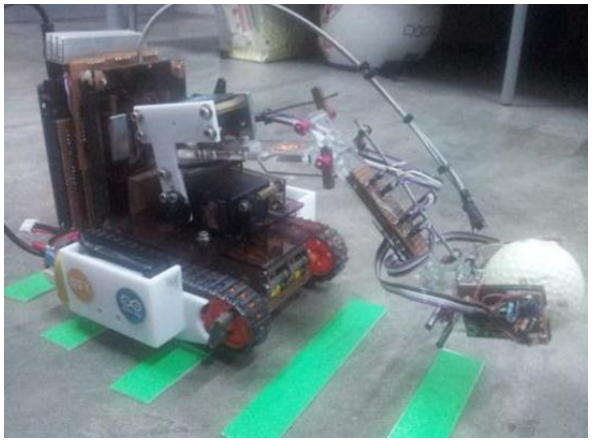

Figure 2.8: Structure of the mobile robot

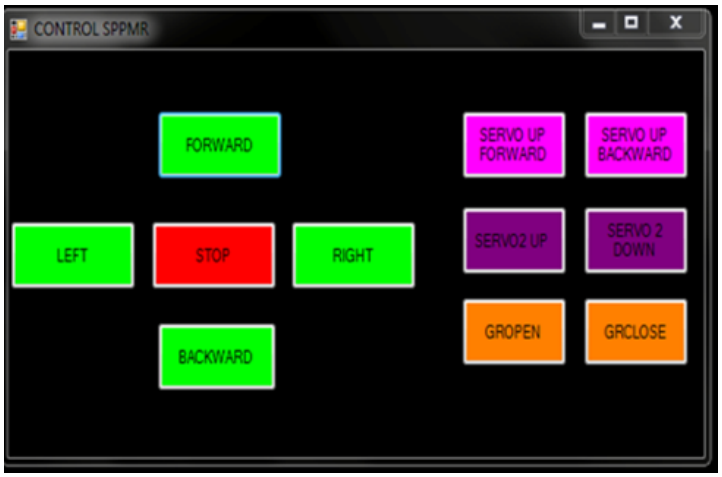

Figure 2.9: GUI controller design

The mobile robot works autonomously where the mobile robot search the object by using IR sensors, and then pick the object using a manipulator (the arms and the gripper) and bring the object to another location. The second mode is where the mobile robot is manually control via a personal computer through the Graphical User Interface (GUI). The GUI has been developed using the Visual Basic software. The search, pick and place mobile robot is equipped with wireless communication module so that the mobile robot can be controlled wirelessly. Xbee module is used as the transmitter and receiver of data signal.

2.5.3 SCORBASE for SCORBOT-ER 2u/4u

SCORBASE for SCORBOT-ER 2u/4u is a robotics control software package for robot programming and operation [15]. This robot is available in the Faculty of Electrical Engineering, Universiti Teknologi Malaysia. Figure 2.11 shows the graphical user interface to control the robot arm by two operation modes which are, normal robot movement and manual movement.

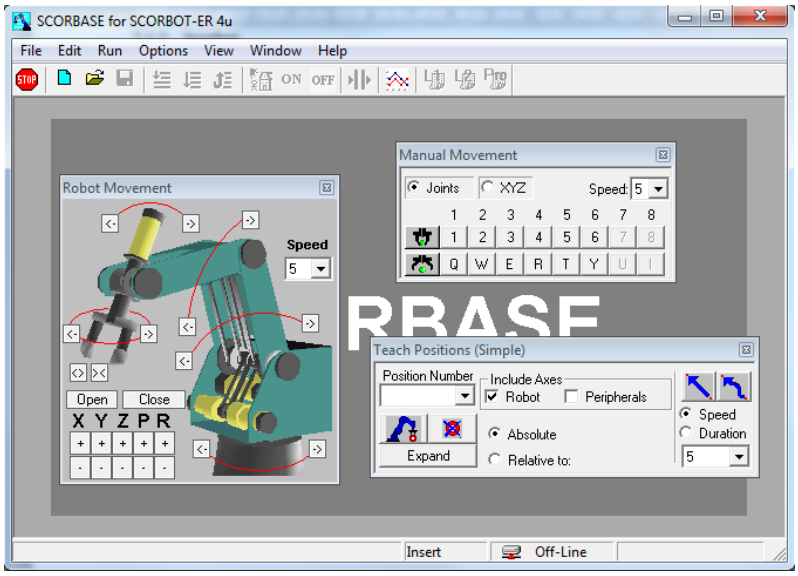

Figure 2.10: GUI of the SCORBASE

2.5.4 Fischertechnik

Invented by Artur Fischer and produced by GmbH in Waldachtal, Germany. Fischertechnik is used in education for teaching about simple machine as well as motorization and mechanisms. The company also offers computer interface technology, which can be used to teach the theory of automation and robotics.

More recently, Fischertechnik has started producing a whole line of kits specialized for the construction of particular models, like boats, airplanes, bridges, cranes, etc. This is something of a departure from their traditional niche producing

generic sets from which (literally) hundreds of different models can be built. Fischertechnik has also started producing advanced robotic sets, including battery packs, remote controls, and programmable control boards. Figure 2.11 shows a robot sold by Fischertecnic.

Figure 2.11: A robot sold by Fischertechnic

2.6 Summary

This chapter has discussed about the microcontroller, wireless device, and integrated circuit. In addition, the related works also being briefly discussed. All of these basic information about the technical side of the robot are very important in completing this project.

CHAPTER 3

SYSTEM DESIGN

3.1 Introduction

This chapter discusses the design of the overall system. It includes software development tools, design of the teaching and learning module, design of the hardware, and the design of the graphical user interface.

3.2 Software Development Tools

Microsoft Visual Studio 2010 Ultimate, and Arduino IDE will be used in the software development.

3.2.1 Microsoft Visual Studio 2010 Ultimate

To create the teaching and learning module, this project used Microsoft Visual Studio (Visual Basic Language) as a platform to write the computer program. Visual basic is selected because of its simplicity and it is easier to be programmed compared to other software.

Based on Figure 3.1, to build the Teaching and Learning Module, start the Microsoft Visual Studio 2010. Then, the Visual Basic template is chosen to create Windows Form Application. The reason to choose Windows Form Application is to create the education module including the graphical user interface (GUI) of the robot.

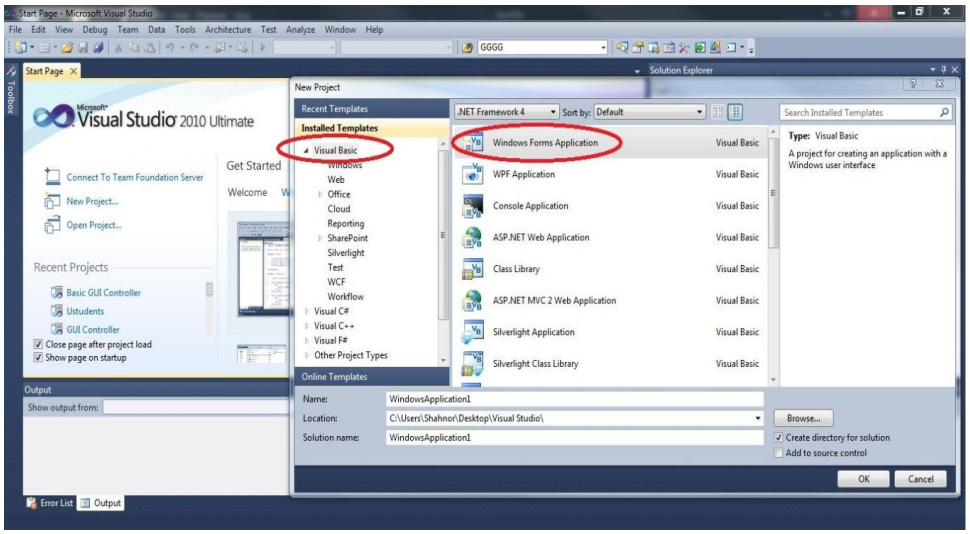

Figure 3.1: Microsoft Visual Studio 2010

3.2.2 Arduino IDE

The arduino microcontroller comes with its arduino IDE (intergrated development environment) to make it possible to be programmed. The language is almost the same as C language. This IDE is used to program the robot arduino

(Arduino Mega) and transmitter microcontroller (Arduino Uno). Figure 3.2 shows the integrated development environment of the Arduino.

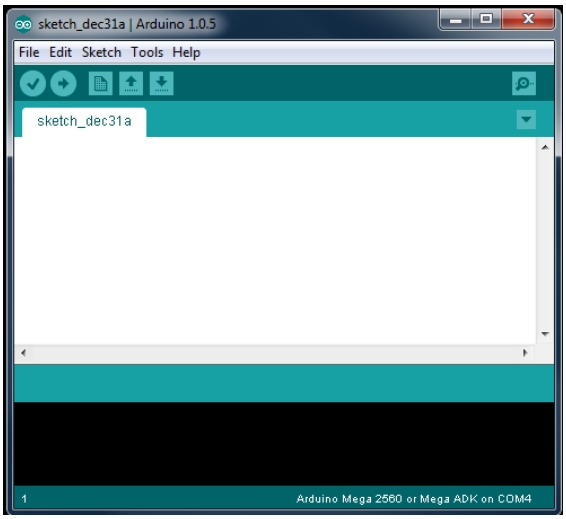

Figure 3.2: Arduino IDE

3.3 Teaching and Learning Module Design

The teaching and learning module based on pick and place mobile robot are designed to have a parent window as a main window. Based on Figure 3.3, we can see the overall block diagram of this program. From the main window, teaching and learning module based on pick and place mobile robot, it can generate a lot more other windows.

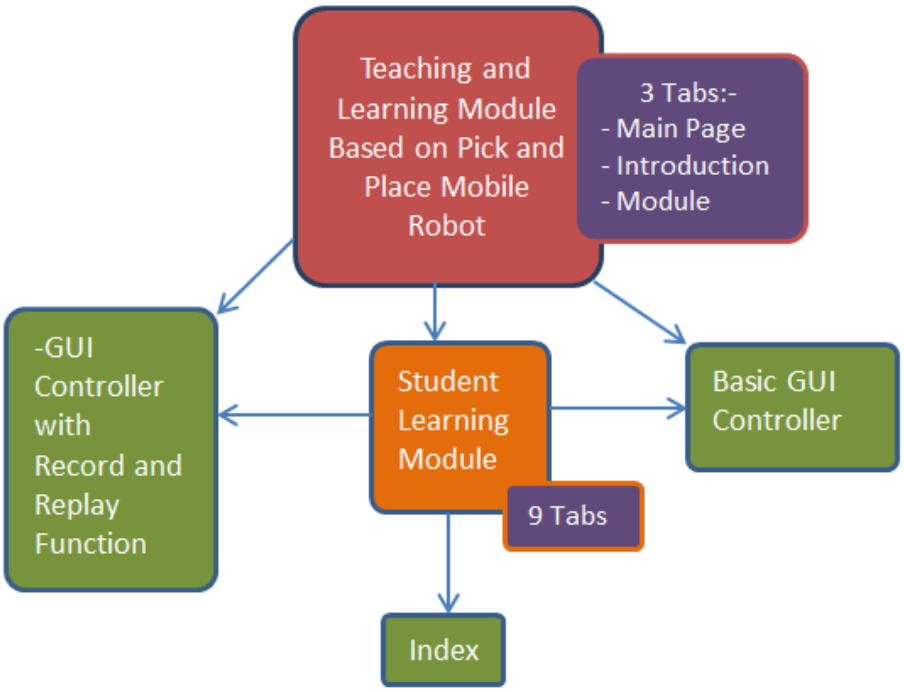

Figure 3.3: Block diagram of the computer program

3.3.1 Main Program

Main program of the teaching and learning module basically has several strip menus and tabs to generate other application. This is a kind of GUI to let the user use the program and command what to do. Figure 3.4 shows the start page of the program.

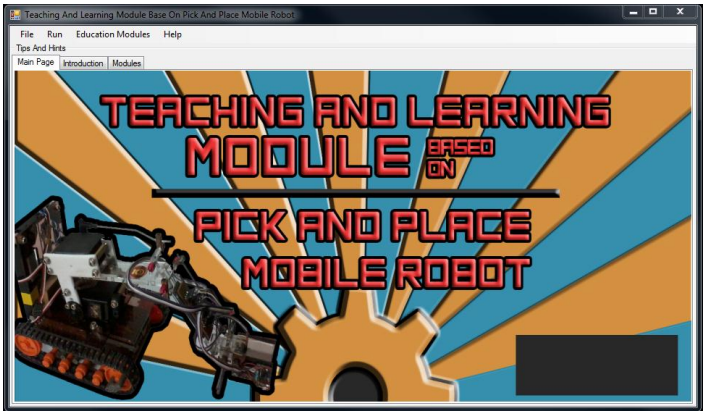

Figure 3.4: Main program of the software

3.3.2 Learning Module Overview

The project also equipped with slides for the student to go through and learn some of the robotic information. These slides contain information regarding the pick and place mobile robot so that it can help students to learn about the robot that they will use. Other than that, the program such as graphical user interface to control the mobile robot also have been put in some of the slides.

3.4 Hardware Design

This project use the existing pick and place mobile robot. All the mechanical part of this project is unchanged. However, there are some mechanical problems regarding the wheels and gripper that need to be repaired. These caused some part of the mechanical works need to be done to revive this robot. These includes changing broken gear in the gear box, repairing the servo motor attachment to the arm, and the gripper part.

3.4.1 Overall Circuit Design

Based on the Figure 3.5, from the computer (laptop) that have the SPI communication with Arduino, the data is able to be sent to the nRF24L01. This nRF24L01 will later transmit the signal to the other nRF24L01 wirelessly. As a main microcontroller, Arduino Mega is connected to the nRF24L01, motor drivers, sensors and two servo motors. This circuit design consist of two DC power supply to make the robot operate smoothly.

The overall schematic of the robot control system schematic diagram and wireless system schematic diagram are as been attached in the Appendix A and Appendix B.

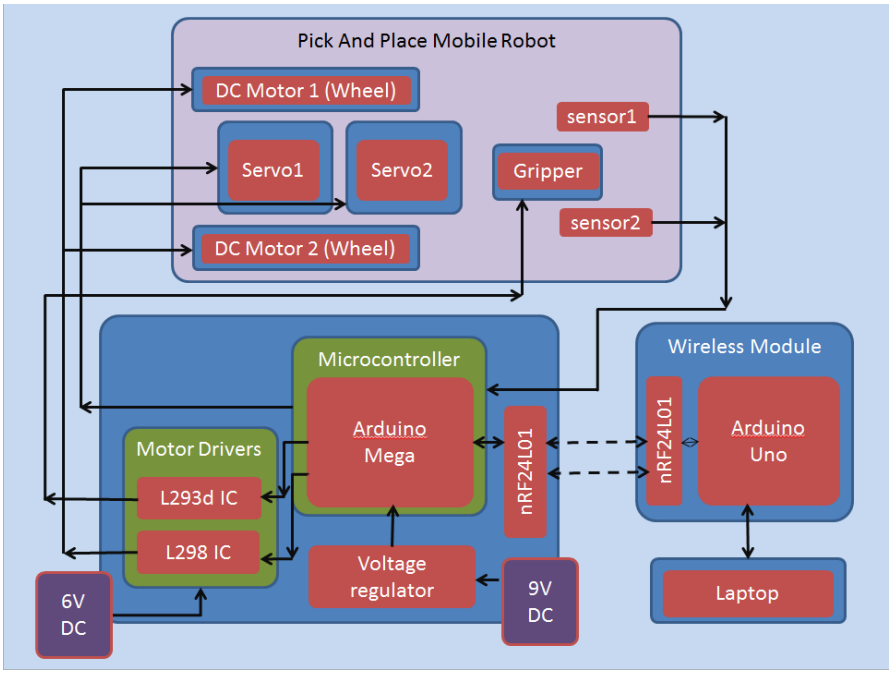

Figure 3.5: The block diagram of the electronic parts

3.4.2 Robot Microcontroller

By using the Arduino Mega, the robot now possible to do the pick and place operation. The microcontroller used to control three DC motors, two servo motors, two motor drivers, nRF24L01 communication module and other sensors. Due to the such many input and output, The arduino Mega are chosen instead of Arduino Uno because it have much more input/output pins. The microcontroller is attached behind the mobile robot as can be seen in Figure 3.6.

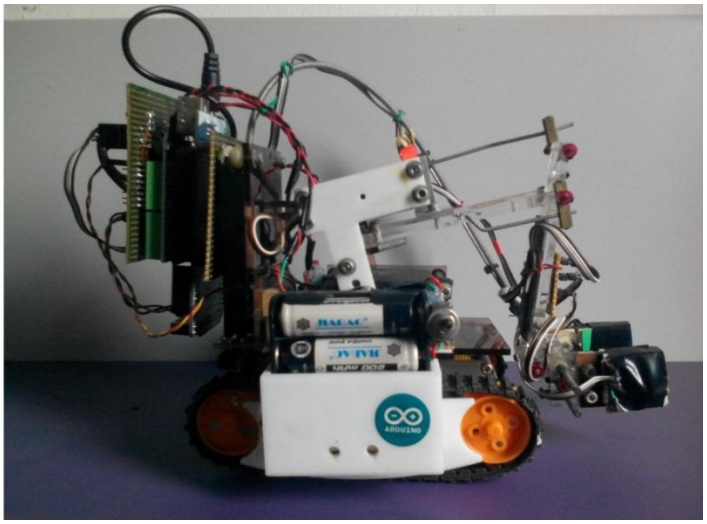

Figure 3.6: The hardware of the mobile robot

3.4.3 Motor Driver

The motor driver L298 shield is attached to the Arduino Mega behind the mobile robot. This motor driver is capable to supply current up to 2A to both wheel motors. To control the motor rotation speed, this motor driver used PWM which can be obtained from Arduino's PWM output Pin 5 and 6.

Other than that, L293D also used to control the gripper motor. This IC is much simpler and easier to be programmed. The disadvantage of using this IC it only can supply up to 0.6A current that is not enough to drive the wheel motors.

3.4.4 Communication System Circuit Design

This project used nRF24L01 as the wireless communication device. This device is used because it is cheaper and easy to get from the market as compared to Xbee communication module. To make the wireless transmission possible, the other additional microcontroller is needed to control the nRF24L01 operation. This microcontroller also connected to the computer USB port to retrieve the information from the GUI program.

Figure 3.7 shows the complete system of the communication module. One of the nRF24L01 is attached to the robot' microcontroller and the other nRF24L01 is attached to the Arduino Uno that will be connected to the computer. The schematic of this circuit also can be seen on Appendix A and Appendix B.

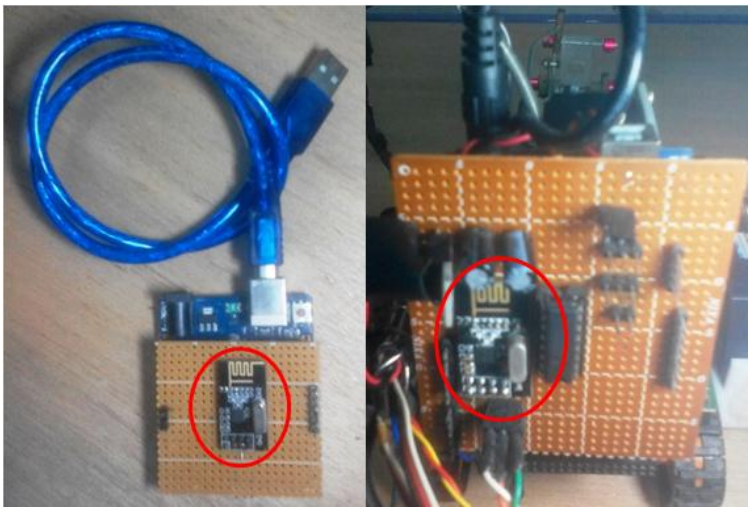

Figure 3.7: The hardware of the communication module

3.5 Graphical User Interface Module

3.5.1 Robot Microcontroller

In order to make the robot operates as desired, the Arduino Mega that have been attached to the robot need to be programmed. Based on Table 3.1, we can see that when a shortcut key is pressed, the motor wheel will only move in several second. For the servo motors that used to move the robot arms, the servo will move from the initial position to the next position as can be seen in Table 3.1.

Table 3.1: Robot motor operation

Operation		Description		Key
		Motor Wheel		
		Left Motor	Right Motor	
Wheels Operation	Forward	Forward 5s	Forward 5s	W
	Reverse	Reverse 5s	Reverse 5s	S
	Turn Left	Stop	Forward 5s	A
	Turn Right	Forward 5s	Stop	D
	Tilt Right 1	Forward 2s	Stop	E
	Tilt Right 2	Stop	Reverse 2s	C
	Tilt Left 1	Stop	Forward 2s	Q
	Tilt Left 2	Reverse 2s	Stop	Z
		Servo Motors		
		S3802	S3003	
Arm Operations	Front Arm Push	-	Position 80 to position 1	U
	Front Arm Pull	-	Position 1 to position 80	I
	Middle Arm Up	Position 70 to position 94	-	J
	Middle Arm Down	Position 94 to position 70	-	K
Grippe		Gripper Wheel		
	Close	Spin Clockwise 0.25s		M
	Open	Spin Anticlockwise 0.25s		N

3.5.2 Developing and Programming the Teaching and Learning Module

A graphical user interface is a type of user interface that allows users to interact with electronic devices with images rather than text commands [16]. GUI also used in computers, gaming devices and portable video player.

Visual Basic is a third-generation event-driven programming language and integrated development environment (IDE) from Microsoft [17]. In typical application of visual basic, it let the user create their application or simple software. This will make the complicated program look simpler and easier to be understood rather than a bunch of letter in a normal debug window.

3.5.2.1 Creating the Main Program

Based on Figure 3.8, the New Project Page has three templates of project which are Visual Basic, Visual C# and Visual C++. Since we are going to use Visual Basic as a platform to build the education module, we shall select Visual Basic. As we are going to learn to create windows Applications, we will select Windows Forms Application.

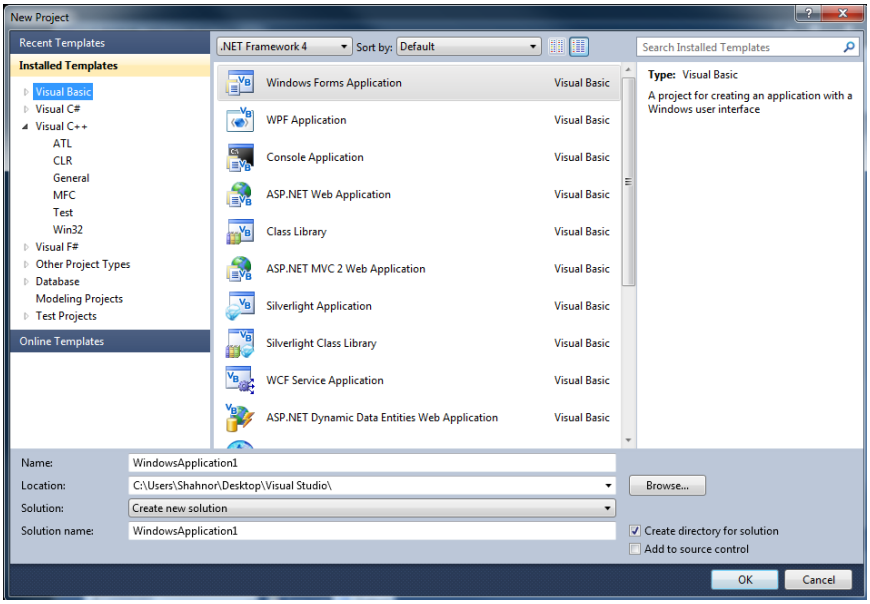

Figure 3.8: Visual Studio 2010 Project Page

Visual Basic 2010 comprises a few windows, which are the Form window, the Solution Explorer window and the Properties window. It also consists of a toolbox which contains many useful controls that allows a programmer to develop his or her visual basic programs. Those windows are shown in Figure 3.9.

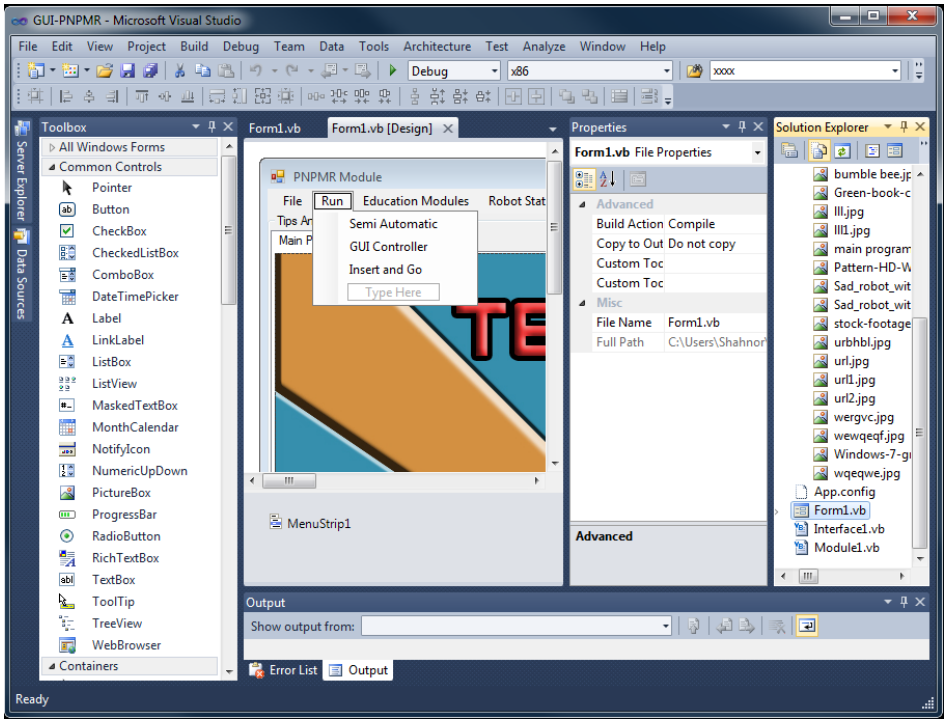

Figure 3.9: Visual basic in Microsoft Visual Studio 2010

After the form is debugged, the new window will appear. When some of button in the GUI clicked, the specific operation will happen to the program. For instance, it will show a new window named as “GUI Controller”. The codes behind this click button are shown in the Figure 3.10. This button will do the operation of calling other program from specific location in the computer using “Process.Start” command.

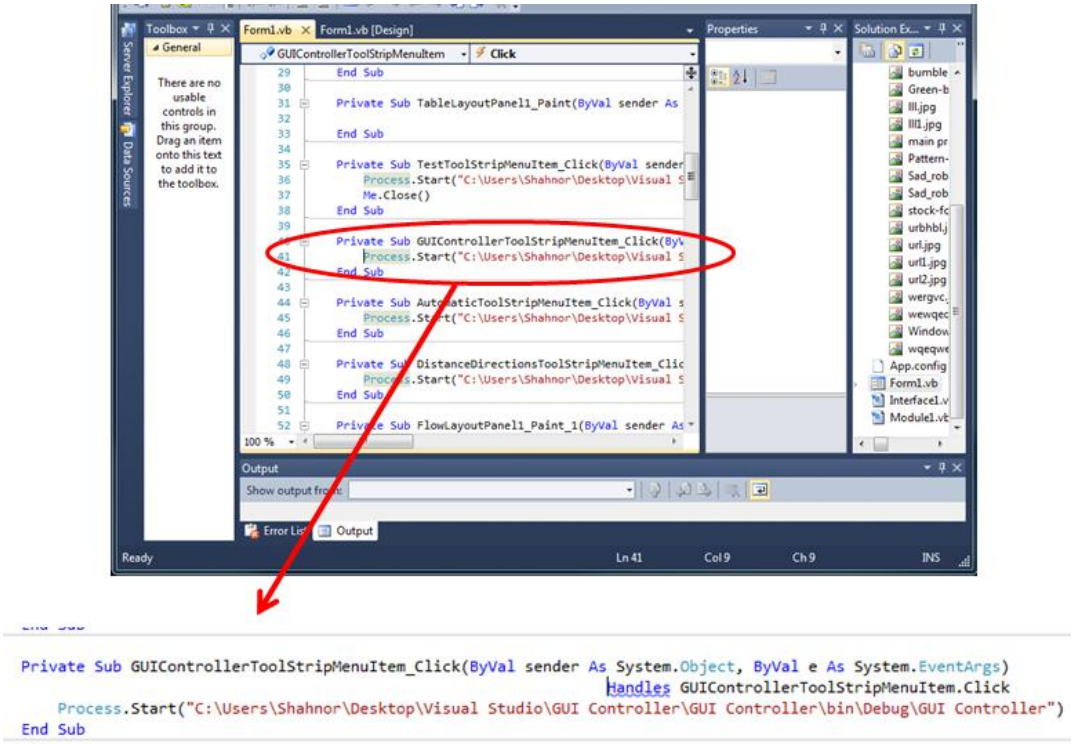
Private Sub GUIControllerToolStripMenuItem_Click(ByVal sender As System.Object, ByVal e As System.EventArgs)
Handles GUIControllerToolStripMenuItem.Click
Process.Start("C:\Users\Shahnor\Desktop\Visual Studio\GUI Controller\GUI Controller\bin\Debug\GUI Controller")
End Sub

Figure 3.10: The source code of the button

3.5.2.2 Creating Basic GUI Controller

Figure 3.11 shows the complete computer program that can be used to control the robot operation. This program is called as Basic GUI Controller. The ‘Initiate Robot’ button is used to reposition the arm to its original position. For the buttons inside the ‘Robot Movement’ box is used to control robot wheels and the rest of the

buttons are used for gripper and arms. This section will discuss about the developing process of this basic GUI controller.

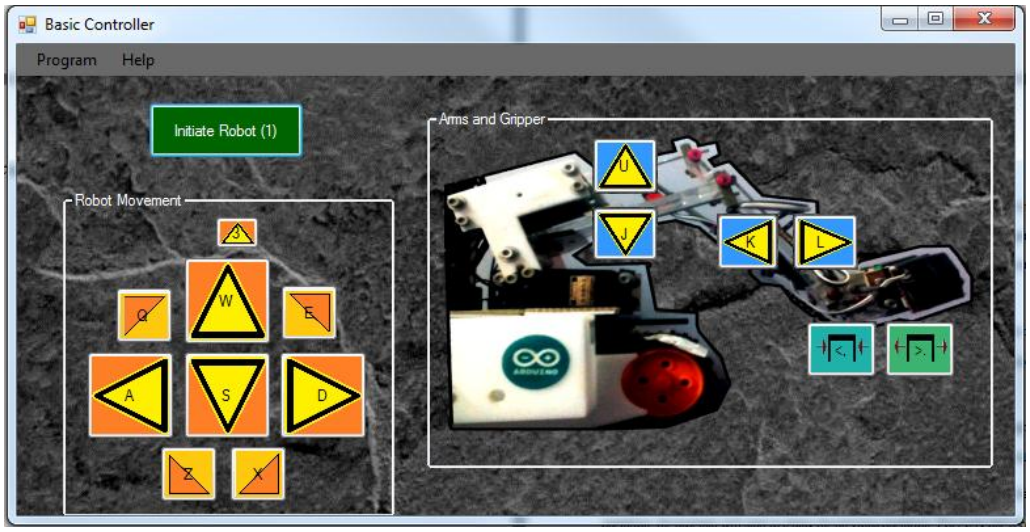

Figure 3.11: Basic GUI Controller

After Microsoft Visual Studio 2010 opened and Visual Basic template is chosen to create Windows Form Application, the program is ready to be constructed. For the basic robot controller, the GUI button can be created by dragging the button tool from the toolbox to the Windows Form Application. Each of these GUI buttons contains code inside it to do the specific operation. Other than that, Serial Port components also need to be added to make the serial peripheral communication possible.

To create a program that attractive to the student, a good graphic and background of the software need to be modified. To do this, change the background properties of each of the components inside the Windows Form Application. Figure 3.12 show the development of the GUI controller.

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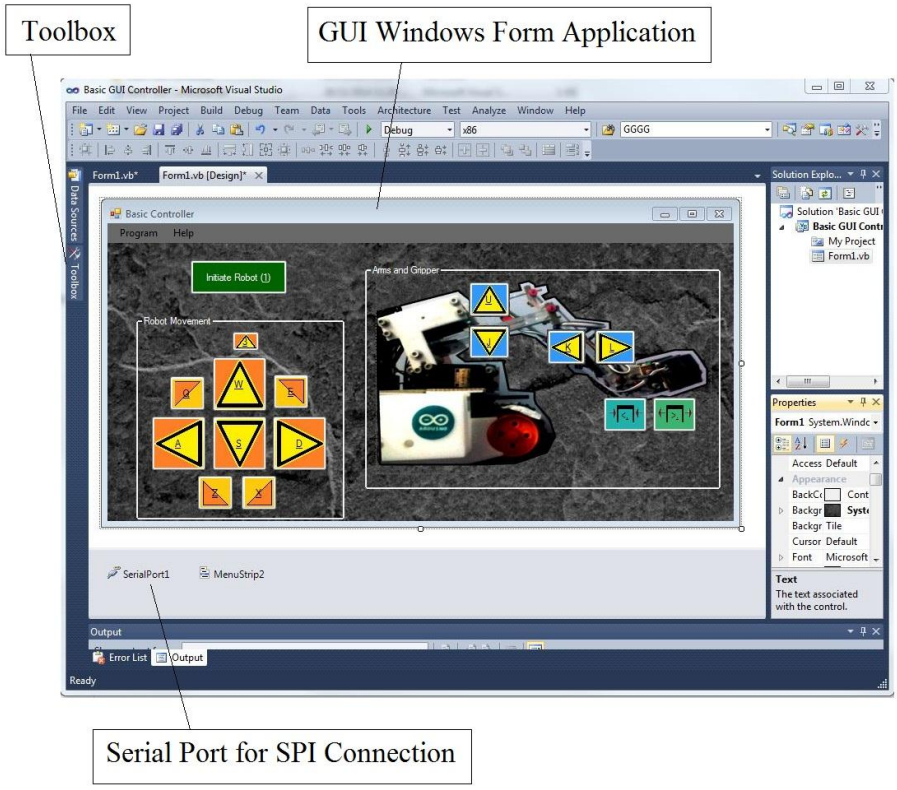

Figure 3.12: The development of the software

This Basic GUI Controller also equipped with shortcut button to make the robot control easier and faster. The user can just press the button on the computer keyboard to send the operation data to the mobile robot. The shortcuts of the buttons are as shown in the GUI. This can be done by adding '&' before the character that will be the shortcut key. This is shown in the Figure 3.13.

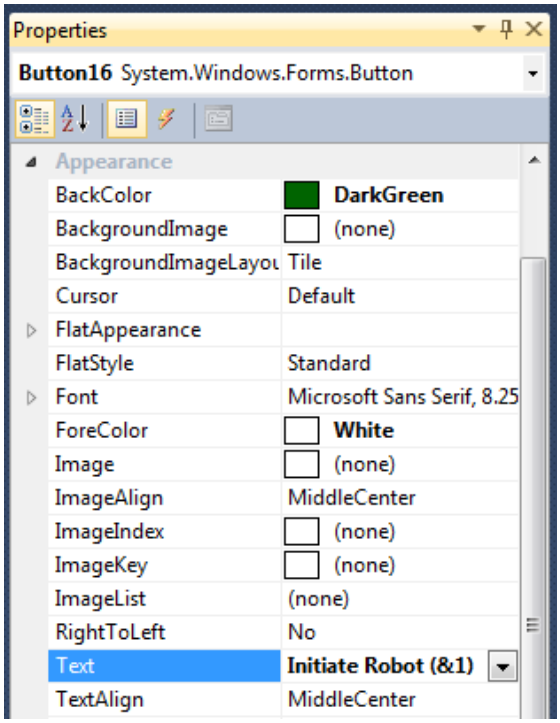

Figure 3.13: The properties of button 1

3.5.2.3 Creating GUI Controller with record and replay function

Figure 3.14 shows GUI to control the mobile robot. This GUI is created with dual-function which are to control the robot and at the same time also can replay the previous operation. Behind those buttons, many type of command are used in order to make this program and the robot working as desired.

Other feature in this GUI is the user can observe the operations that in progress in the 'Recorded Operation' box. The total operation also shown in the 'Total Codes' box. When the Button 5 on the computer keyboard pressed, which stand for Replay operation, the program will start to replay the previous operation. For every one second interval, the counter and codes box will write the operation that plays in that particular time.

Figure 3.14: The Visual studio showing GUI Robot Controller

A. Creating and Writing Files

To make the program to be capable of recording and displaying the operation that have been done, a text file need to be created in order to save the operation. This file is named as myFile.txt that will be created on the desktop folder in the computer. In Figure 3.15, the write variable is defined as streamwriter for writing character to a stream in a particular file.

```
Dim write As StreamWriter
Dim read As StreamReader
```

Figure 3.15: Public class definition of write and read

Based on the Figure 3.16, the command of *File.AppendText("...")* will create and write "W" the myFile.txt file if there is no existing file there. But if myFile.txt already created there, this command will just write "W" without erasing the previous data (characters).

```
write = File.AppendText("C:\Users\Shahnor\Desktop\myFile.txt")
write.Write("W")
write.Close()
```

Figure 3.16: Code to create the file and write the letter W

B. Deleting File and Clearing text boxes

Figure 3.17 shows how the operation of clearing textboxes and list boxes could be done. For the process of clearing text boxes, an empty file needs to be created inside the computer. For this project, it is named as Kosong.txt that is placed in a specific folder as shown in the Figure 3.18. Then, the program will copy characters inside the Kosong.txt file to be put in the textbox1 (Recorded Codes) and textbox2 (Total Codes).

```
'resetButton
Private Sub Button18_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button18.Click
    read = File.OpenText("C:\Users\Shahnor\Desktop\Visual Studio\Kosong.txt")    'Kosong.txt is an empty file
    KotakTeks.Text = read.ReadToEnd                                              'Put Kosong.txt to the text box
    KotakTeks2.Text = read.ReadToEnd                                             'Put Kosong.txt to the text box
    ListBox1.Items.Clear()
    ListBox2.Items.Clear()
    read.Close()
    nMula = 0
    File.Delete("C:\Users\Shahnor\Desktop\myFile.txt")                           'delete myFile.txt
End Sub
```

Figure 3.17: Clearing textboxes, clearing list boxes, and deleting my.File.txt

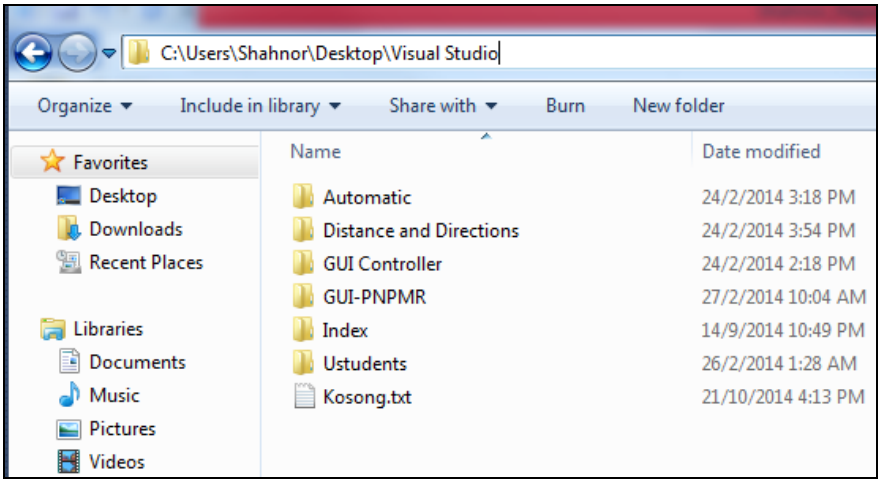

Figure 3.18: Kosong.txt file

On the other side, to clear the items inside the ListBox1 and ListBox2 the codes *"ListBox1.Items.Clear()"* and *"ListBox2.Items.Clear()"* are used. This code will easily wipe all the previous information in that two list boxes.

Back to Figure 3.17, in order to delete the existing file, myFile.txt that have been stored in the desktop, just simply using operation delete. File.Delete("C:\Users\Shahnor\Desktop\myFile.txt").

C. Array for Record the Operation Character

An array is a variable that holds multiple values of the same type. For this program the array of RekodArray[X]. X can be a value from 0 to 100. This array will holds a string value such as (W, A, S, D, N, J, U, I, K, and M) when these button pressed. Figure 3.19 shows how to define RekodArray() as string. The variable nMula and M also used to make this array because it will change by time to time. *RekodArray(nMula)* and *RekodArray(M).* Based on figure 3.20 the sring W is sent to *RekodArray(nMula).*

```
Dim RekodArray(100) As String
Dim nMula As Integer = 0
Dim M As Integer = 0
```

Figure 3.19: Public Class definition of RekodArray()

```
'send to array
RekodArray(nMula) = CStr("W")
KotakTeks2.Text = CStr(nMula + 1)
nMula = nMula + 1
```

Figure 3.20: Retrieving string W to the array in Private Sub

D. Timer

Timer is used in order to make the one second time interval of writing Counter box and Codes box. Other than that this timer also used to set the time when to send the string contained in the RekodArray(M) to the port3. Based on Figure 3.21, the timer is set to repeat the loop for every 1000 milliseconds.

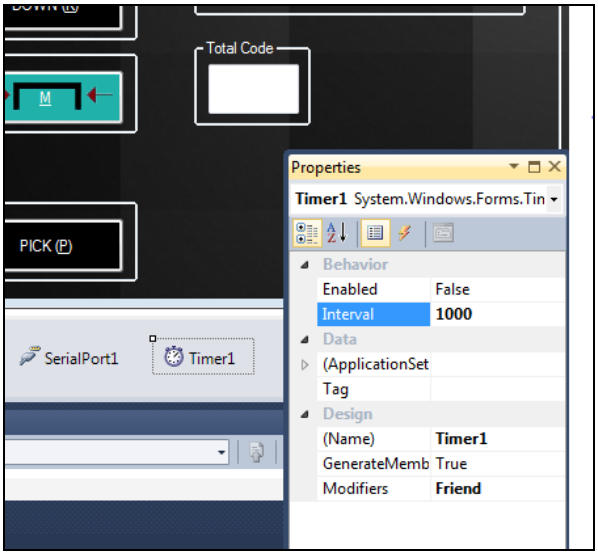

Figure 3.21: The timer properties

To start the timer loop, the command Timer1.Start() is used. To stop this looping program, Timer1.Stop() is used. Each loop interval is 1000 milliseconds or also equal to 1 second. Figure 3.22 shows, the replay operations of the program. The Counter and Codes List box will update every one second until the program stopped.

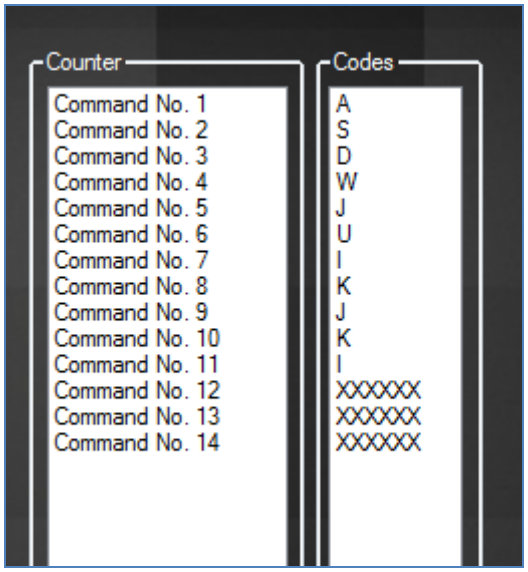

Figure 3.22: The counter listbox and codes listbox

Figure 3.23 shows that the operation done by the time in each second. The ListBox2(Counter list box) and ListBox1(Codes box) will print the Command No. and string of RekodArray(). At the same time, in will send the string of RekodArray() to the serial port.

```
Private Sub Timer1_Tick_1(ByVal sender As System.Object,
    x = x + 1
    ListBox2.Items.Add("Command No. " + x.ToString)
    ListBox1.Items.Add(RekodArray(M))

    SerialPort1.Open()
    SerialPort1.Write(RekodArray(M))
    SerialPort1.Close()
    M = M + 1
End Sub
```

Figure 3.23: Timer loop

3.5.3 Wireless Communication Module

In this project, the designed GUI is the main controler to make the connection between the computer and the mobile robot. In robot operation process, the communication between the computer program and the mobile robot need to be done. The robot will operate wirelessly according to the input from the GUI controller. This wireless communication module is about the connection between two microcontrollers. Two nRF24L01 are used for the communication between the two microcontroller. Figure 3.24 shows the source code of GUI program to send string to the Arduino. Meanwhile in the Figure 2.35, the serial properties especially its baud rate and the port name need to be the same with the Arduino's.

```
Private Sub Button4_Click(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles Button4.Click
    SerialPort1.Open()
    SerialPort1.Write("A")
    SerialPort1.Close()
End Sub
```

Figure 3.24: Source code to send string

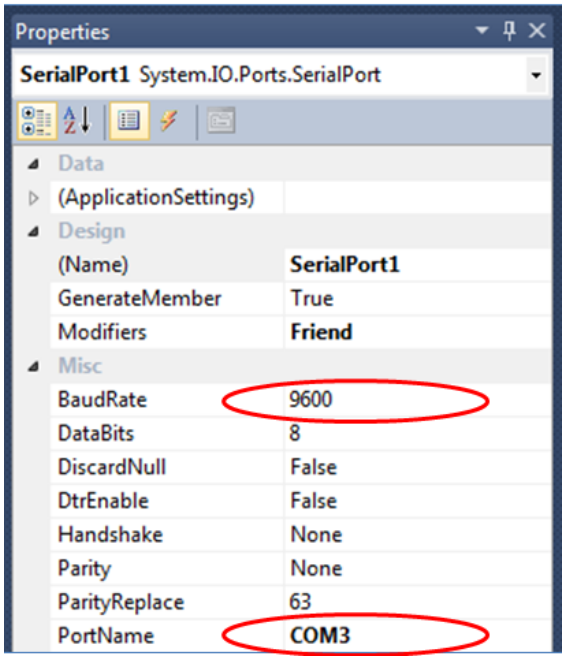

Figure 3.25: Serial port properties

Figure 3.26 shows the source code of the wireless communication program of the system. For receiving and transmitting address, it must be the same with the other Arduino to make it connected to each other.

```
void setup()
{
  Serial.begin(9600);
  Mirf.spi = &MirfHardwareSpi;
  Mirf.csnPin = 9;                  // define CSN pin of the arduino
  Mirf.cePin = 8;                   // define CE pin of the arduino
  Mirf.init();
  Mirf.setRADDR((byte *)"00008");  // receiving address from other arduino
  Mirf.setTADDR((byte *)"00008");  // transmitting address from other arduino
  Mirf.payload = sizeof(mypacket); // up to 32 byte only
  Mirf.channel = 100;
  Mirf.config();
}


void loop()
{
  while(!Mirf.dataReady()&&!Serial.available())
  {
  //program here
  }
  Mirf.getData((byte *) &mypacket);    //Get data from GUI or serial (computer)
```

Figure 3.26: Arduino communication source code

3.6 Summary

This chapter has discussed the details of the development of the project. The robot hardware, microcontroller used,wireless communication module, GUI robot controller and the development of the teaching and learning module based on pick and place mobile robot have been explained.

CHAPTER 4

EXPERIMENTAL RESULTS AND DISCUSSION

4.1 Introduction

This chapter is going to review the experimental results and the discussion of the project. These include test run on the education module, test on robot operation controlled by GUI controller, test on the ability to record operation, test on ability to replay saved operation, and test on wireless communication.

4.2 Test Run of the Education Module

This teaching and learning module base on pick and place mobile robot consists of one main program and five other minor programs which have been discussed in Chapter 3. The GUI buttons working normally except some of the buttons that has unspecific operation. These buttons are actually a way to improve this education module. The tests of the programs are as shown in Figure 4.1. All

those windows are functioned well. The transmitter needs to be connected to the computer to make the program fully functioning.

Figure 4.1: Windows of the whole program

4.3 Test on Robot Operation Controlled by GUI Controller

To conduct this test, Basic GUI controller need to be run as can be seen in Figure 4.2. Then, connect the cable of the transmitter to the computer and on all the switches of the robot.

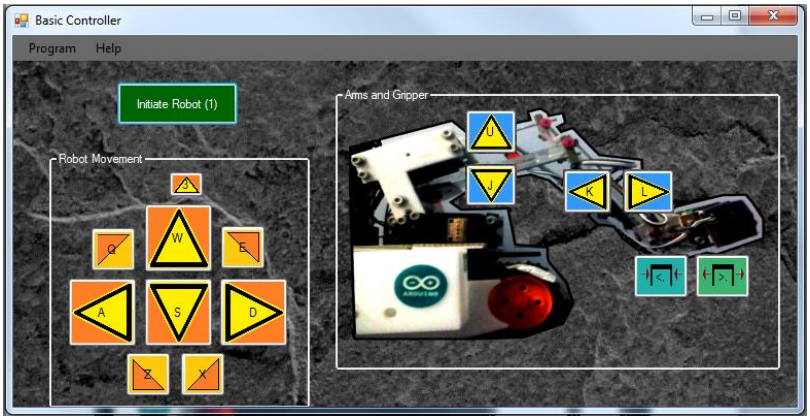

Figure 4.2: Basic GUI controller

When the “Initiate Robot” button pressed, the robot gripper went to the default position. It is programmed to do so, because to place the griper on the position where the robot can move and pick the object easily. Figure 4.3 show the default position of the arms and gripper position after the button was pressed.

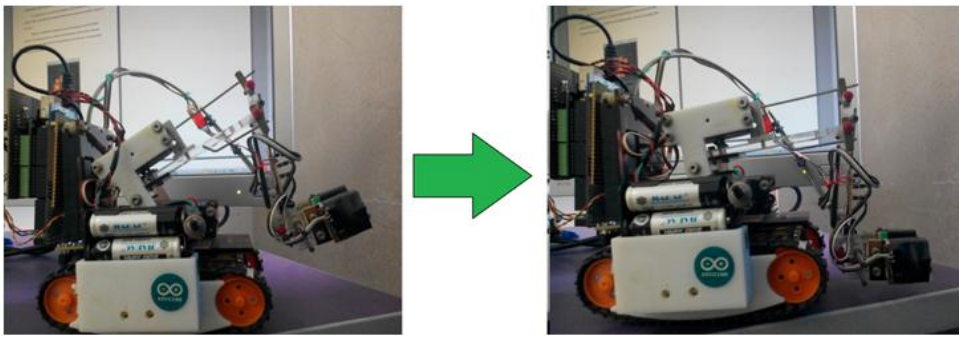

Figure 4.3: Position of arms and gripper

After that, the robot is ready to do the operation using the GUI controller. Based on Table 4.1, the operations of the robot are experimented by pressing the

keyboard of the computer. The result whether the operation successfully done or fail are recorded. This experiment repeated three times to ensure consistency of the GUI controller performance. As a result, the robot is confirmed can be controlled successfully using GUI controller.

Table 4.1: Test on the robot operation controlled by GUI controller

Shortcut Key	1	3	Q	W	E	A	S	D	Z	X	U	J	K	L	<	>
1st test	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
2nd test	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√
3rd test	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

But there is a problem regarding the movement, the left robot wheel move a bit faster than the right one. This makes the robot move a bit to the right while we want it to go straight as can be seen in Figure 4.4.

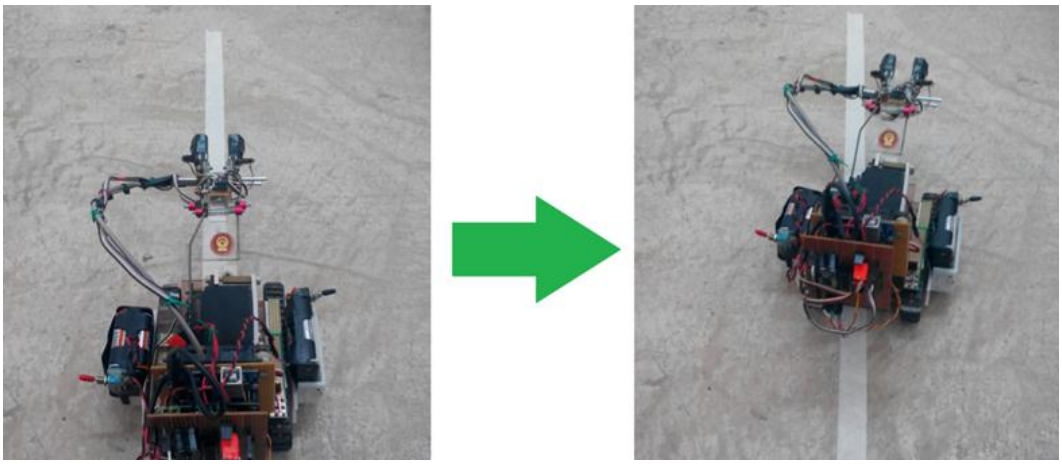

Figure 4.4: Movement test

This problem probabily due to the mechanical problem of the robot. Because of this robot already old, the gears movement in the gear box are not smooth. Other than that, the robot chain wheels also sometimes accidently slipped making the movement not in straight path. But, this problem is just a minor problem as we are using manual operation and can redirect the movement using the GUI controller. Figure 4.5 shows the mobile robot can do the pick and place operation using the GUI controller.

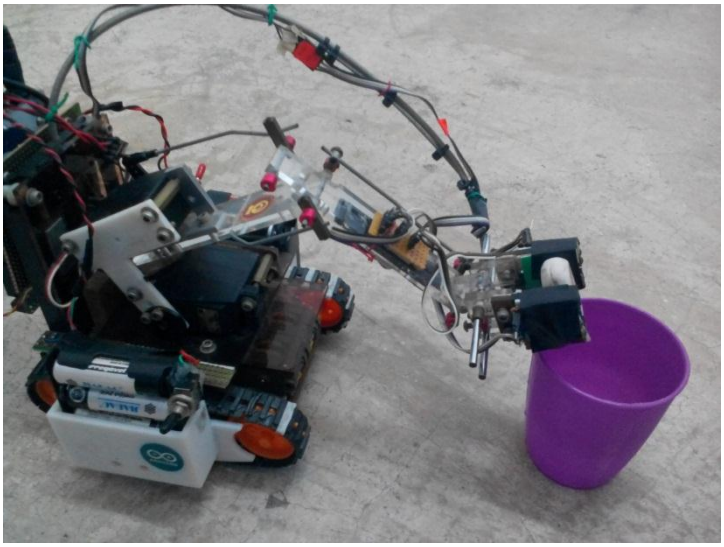

Figure 4.5: Robot doing pick and place operation

4.4 Test on the Ability to Record Operation

The test of the ability to Record the robot operation have been conducted. The program was successfully recorded the operation when the user start to move the robot using the GUI controller. This program saves the operations as a string inside the array in the background process. Figure 4.6 shows operations and the total operations that have been done in the text box.

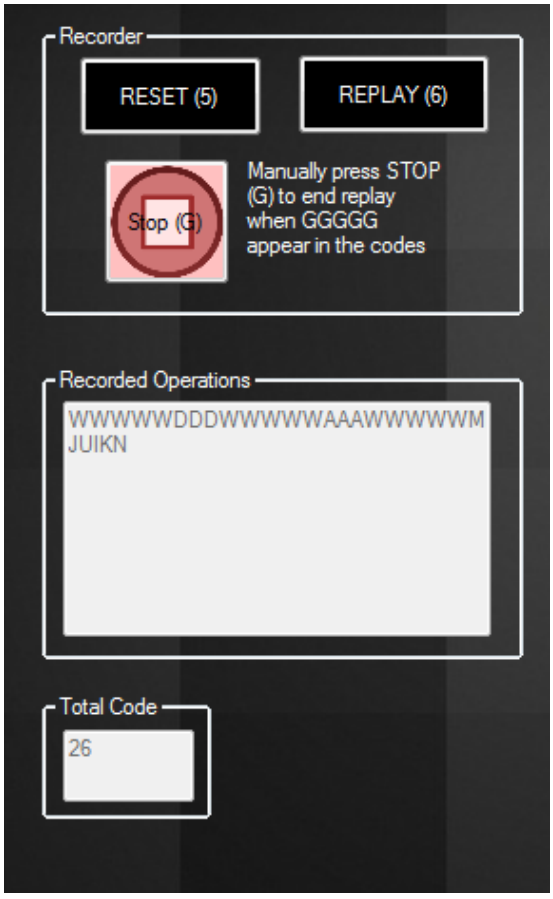

Figure 4.6: GUI recorder

4.5 Test on the Ability to Replay Saved Operation

After recording the robot operation, the user can replay the previous operation that he or she done. The program also has been test to know the successfulness of the program. Figure 4.7 shows the program after the replay operations have been done. For every second, the command number and codes is updated until reach the final code. For every second also, this code string sent to the port (Arduino) to be sent to the robot's microcontroller controller part.

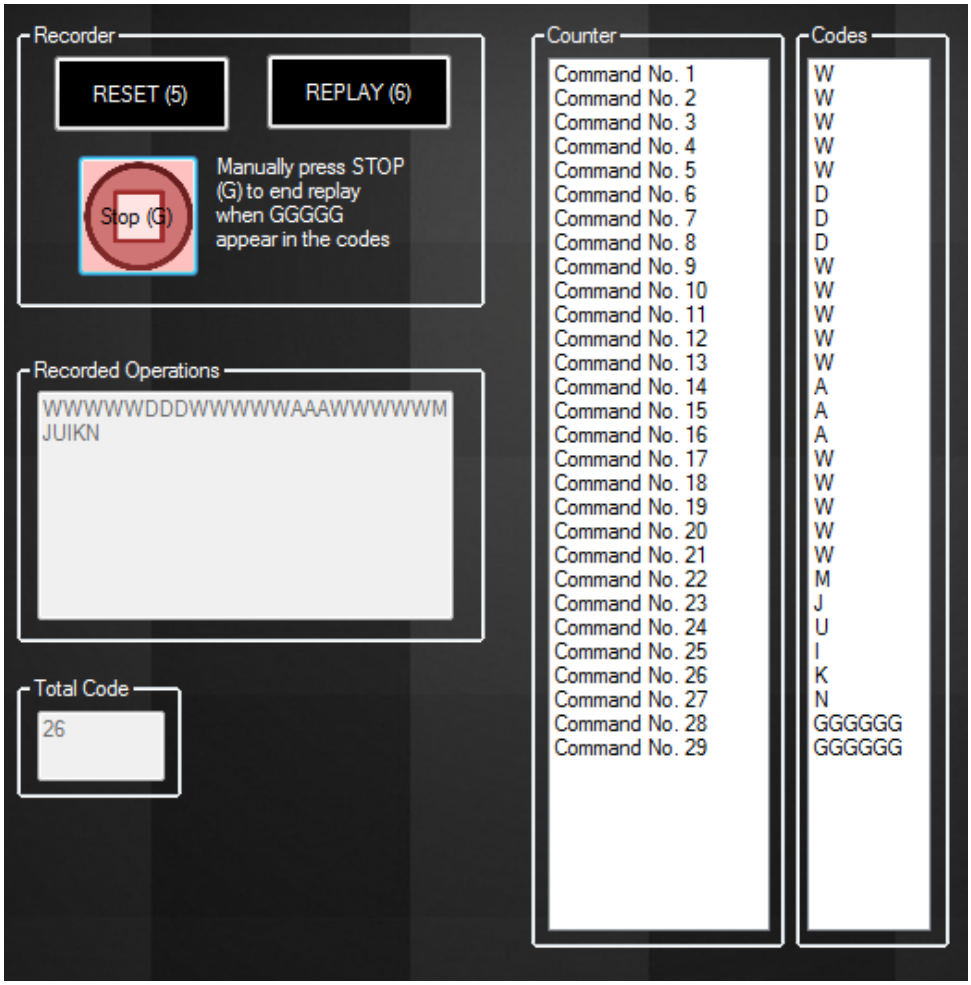

Figure 4.7: Replaying the operation

4.6 Test on Wireless Communication

This test is conducted to know the farthest distance from the computer that can be reached by the robot while still stay connected with the wireless communication. This experiment conducted because in the real world, we do not know the distance from the computer and mobile robot that the student will conduct to control the robot. The experiment was conducted in the clear area that does not have any obstacles in between the transmitter and receiver.

Based on Table 4.2, the successfullness of the wireless communication between computer and mobile robot are recorded. This is done by moving the mobile robot to the farthest distance it can reach. The mobile robot operate smoothly from 0 meter to 26 meter, but when passing 27 meter, the wireless communication started to fail. At this point, the robot can no longer be controlled. The experiment is repeated three times to make sure the consistency of the results.

Table 4.2: Robot wireless communication distance test

Distance between mobile robot and computer (m)	Signal Received		
	First Test	Second Test	Third Test
5	√	√	√
10	√	√	√
20	√	√	√
21	√	√	√
22	√	√	√
23	√	√	√
24	√	√	√
25	√	√	√
26	√	√	√
27	X	X	X
28	X	X	X

4.7 Summary

This chapter has explained about the tests that have been conducted on the teaching and learning module based on pick and place mobile robot. These include test run on the education module, test on robot operation controlled by GUI controller, test on the ability to record operation, test on ability to replay saved operation, and test on wireless communication.

CHAPTER 5

PROJECT MANAGEMENT

5.1 Introduction

This chapter discusses the project Gantt chart and also the estimated cost for the project. By doing the Gantt chart table, students need to follow the given guidelines and timelines. They also need to complete their project on time base on the Gantt chart. By doing the cost estimation, the author will clear on what to buy while conducting the project so that their cash flow is under the expected cost.

5.2 Gantt Chart of the Project

Table 5.1 shows the project Gantt chart for the whole semester. Most of the time is used to do the programming works because it does take time to learn and get familiar with the Visual Basic language. The programming works also includes the robot operation program.

Table 5.1: Gantt chart of the project

Task	Week															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Related Works																
Teaching and Learning Module																
GUI Controller Design																
Communication Module (Wireless)																
Interfacing GUI and Arduino																
Hardware of The Robot																
GUI (Record & Replay)																
Soldering Works																
Proggramming (Arduino and Others)																
Seminar (Preparation and Presentation)																
Thesis Writing																

5.3 The Estimated Cost

Table 6.2 shows the cost invested to build the robot. Meanwhile for the software, it is neglected because the software and the operating system are free of charge.

Table 5.2: The estimated cost to rebuild the robot

NO	ITEMS	QTY	RATE(RM)	PRICE(RM)
1	ARDUINO UNO R3	1	58.00	58.00
2	ARDUINO MEGA	1	68.00	68.00
3	NRF24L01	2	30.00	60.00
4	IC L293D	1	10.80	10.80
5	MOTOR DRIVER L298	1	40.00	40.00
6	VOLTAGE REGULATOR 7805	1	12.00	12.00
7	CAPACITOR	2	1.00	2.00
8	IR SENSOR SET	2	3.50	7.00
9	IR TRANSMITTER AND RECEIVER	2	2.00	4.00
10	RESISTOR	8	0.05	0.40
11	LED	2	0.10	0.20
12	BATTERY HOLDER	2	3.00	6.00
13	RECHARGEABLE BATTERY	L/S	L/S	30.00
14	OTHERS	L/S	L/S	21.60
	DONUT BOARD, WIRE, PINS, SOLDERING IRON			
	CABLE, SCREWS, BOLTS AND NUTS			
			TOTAL PRICE (RM)	**320.00**

5.4 Summary

This chapter has shown the Gantt chart of the project for the whole semester as well as the table for the estimated cost.

CHAPTER 6

CONCLUSION AND RECOMMENDATION

6.1 CONCLUSION

As a conclusion, this project has achieved the objectives. The reliability and the stability of the project is perfect as been expected. The basic GUI controller can now control the robot operation. The GUI controller with record and replay ability also successfully constructed. However, regarding the mobile robot, there are some problems that affect the stability. This is caused by the low performance of the mobile robot wheels mechanical part. But, the arms and the gripper are functioning well.

As the brain of the robot, microcontroller is successfully installed and able to control the robot. The microcontroller will execute the program that has been uploaded to it. The wireless communication module also functioning well. In overall, the teaching and learning module based on pick and place mobile robot has been successfully developed.

6.2 RECOMMENDATION

In the future, there are some improvements can be done to improve the functionality and flexibility of the teaching and learning module. This will make the module more user friendly and can be used for many levels of student. Some of the recommendations are:

i. Simplified the existing mobile robot model so that we can reduce the cost of this robot.
ii. Enhance more advance syllabus based on the curriculum.
iii. Education partnership program.
iv. Enquiry and questionnaire given to the student after using the module. Improve by time to time.
v. Incorporating passive vision system into the existing module.
vi. Active vision system capability to the robot by installing a camera to the robot.

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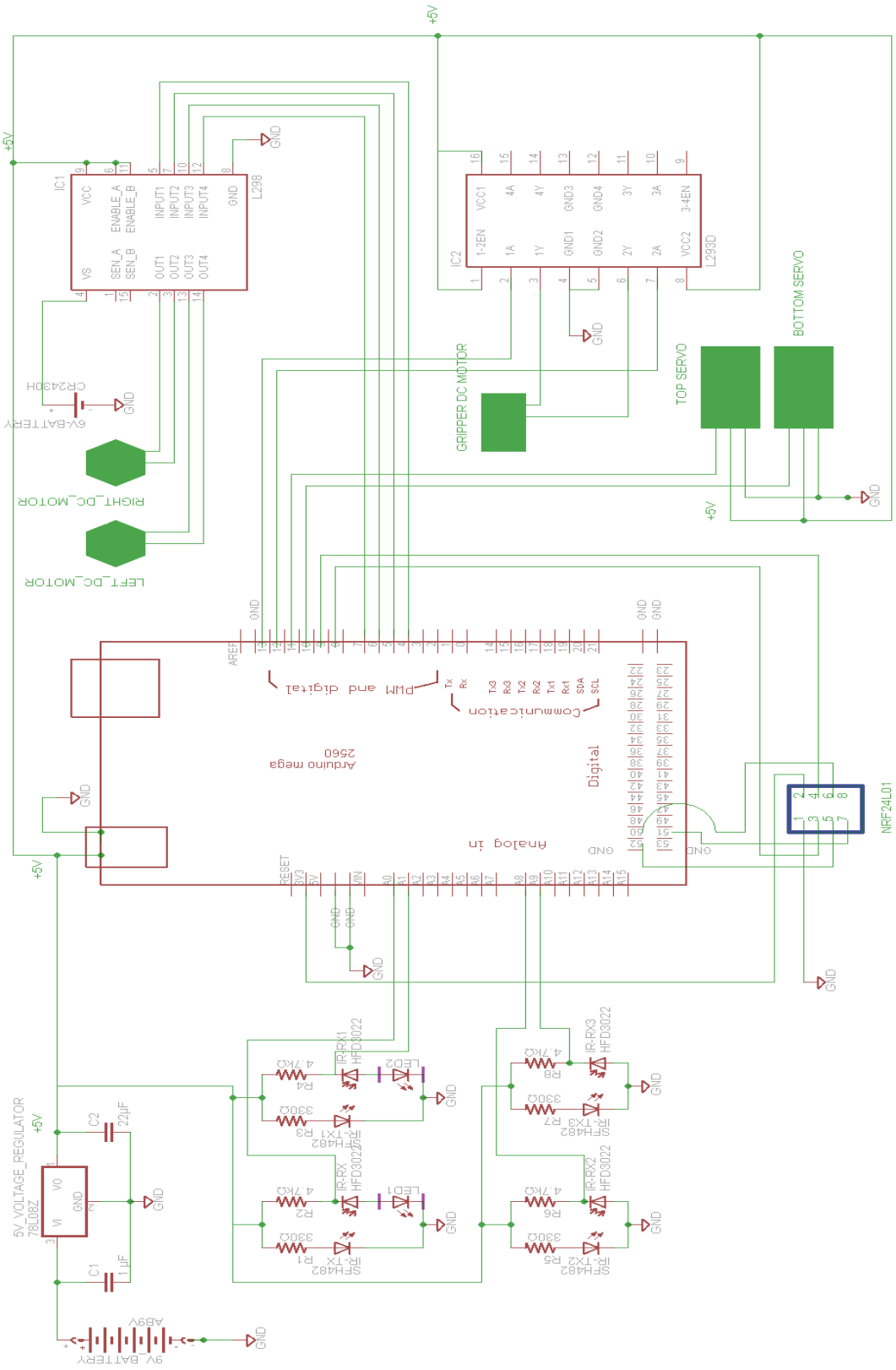
APPENDICES

APPENDIX A

SCHEMATIC OF THE ROBOT CIRCUIT



APPENDIX B

SCHEMATIC OF THE TRANSMITTER CIRCUIT